

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

May 26, 2000

Systems Group Chairman's Factual Report

DCA-00-MA-006

A. ACCIDENT

Operator: EgyptAir
Location: 60 Miles Southeast of Nantucket Island (N40.20, W69.45)
Date: October 31, 1999
Time: 0148 EST
Airplane: Boeing 767-366ER, SU-GAP

B. SYSTEMS GROUP

Chairman: Scott Warren
NTSB
Washington, D.C.

Phase 1:

Member: Peter VanLeynseele
Boeing
Seattle, Washington

Member: Mohamed Sabry Mahmoud Medhat
EgyptAir
Cairo, Egypt

Member: Mohamed A. Hamid Hamdy
EgyptAir
Cairo, Egypt

Member: Maher Ismaiel Mohamed
Egyptian Civil Aviation Authority
Cairo, Egypt

Member: Hani S. Mahmoud
EgyptAir
Cairo, Egypt

Phase II:

Member: Ihab Shaker,
EgyptAir
Cairo, Egypt

Member: David Blanchet,
Boeing
Seattle, Washington

Phase III:

Member: Lori Lee Darrow,
NTSB
Washington, D.C.

Member: Patricia Vitalis,
NTSB
Washington, D.C.

Member: Marieke van Hijum,
NTSB
Washington, D.C.

Member: Hani S. Mahmoud,
EgyptAir
Cairo, Egypt

Member: Michael Marx,
Consultant for Egyptian Civil Aviation Authority
Springfield, Virginia

Member: Wes Kennedy,
Boeing
Seattle, Washington

C. SUMMARY

About 0150 eastern standard time (EST), on October 31, 1999, a Boeing 767-366ER, SU-GAP, operated by EgyptAir, as flight 990, crashed into the Atlantic Ocean about 60 miles south of Nantucket, MA. EgyptAir flight 990 was being operated under the provisions of Egyptian Civil Aviation Regulations Part 121 and United States Title 14 Code of Federal Regulations Part 129 as a scheduled, international flight from John F. Kennedy Airport (JFK), New York, New York to Cairo International Airport in Cairo, Egypt. The flight departed JFK about 0122 EST, with 4 flightcrew members, 10 flight attendants, and 203 passengers on board. There were no survivors. The airplane was destroyed by impact forces. Floating debris from the aircraft was recovered on the morning of October 31, 1999.

The systems group participated in the accident investigation during three phases of activity. The first phase took place during November 30 – December 2, 1999, in Washington, D.C. and consisted of the evaluation of the flight data recorder (FDR) data relative to various potential failure scenarios. The second phase took place in Quonset Point, Rhode Island, and consisted of the examination of aircraft wreckage. The third phase took place in Quonset Point, Rhode Island, and consisted of a metallurgical examination of all of the fracture surfaces present on the recovered components of the longitudinal control system.

D. DETAILS OF THE INVESTIGATION

Phase I:

The Systems Group met on November 30 - December 2, 1999, at the National Transportation Safety Board Headquarters building in Washington, D.C. The group reviewed the FDR data, and discussed potential failure scenarios that might result in aircraft systems characteristics similar to those shown in the data.

The group reviewed the longitudinal control system with a specific item of interest being the elevator motion around the time 1:49:52. FDR data showed that the elevators moved from a trim position of approximately 0.35 to 0.7 degrees to a trailing edge down position of -3.2 degrees (left elevator) and -3.9 degrees (right elevator) within a period of 5 seconds with a majority of this displacement occurring in the first 2 seconds of the period. Within a period of 16 seconds, the elevators had reached a maximum deflection of -4.75 deg (left elevator) and -5.45 deg (right elevator) in the trailing edge down direction.

According to the Boeing maintenance manual, the 767 has two elevators that are attached to the moveable horizontal stabilizer. In normal operation, the left and right elevators move together in response to pilot or autopilot commands. Three independent hydraulic actuators, each of which is powered by a separate hydraulic system, position

each elevator. Commands from the pilot or autopilot are transmitted to the actuators via cables and push rods to the input of the actuators. In response to a position command, the control valves in the three actuators move to an open position, which causes high pressure hydraulic fluid to be directed to the actuator pistons. This causes the pistons to move in the direction of the input command until the desired position is reached. When the actuator pistons reach the commanded position, the feedback linkage moves the control valve back to a closed position and the hydraulic fluid flow is shut off.

In the event of an active failure (hardover or runaway) of one of the actuators, compressible links (pogos) are installed at the input of each actuator. These pogos are designed to provide a means of isolating the failed actuator from the rest of the system and allow the pilots to retain control of the elevators .

At the conclusion of phase I activities, and after evaluating the impact of the potential failure scenarios, the dual elevator actuator failure scenario remained as an item warranting additional investigation.

Phase II:

The Systems Group met at Quonset Point, Rhode Island, from January 5-14, 2000. During that time they sorted and identified components of various aircraft systems for Egypt Air flight 990. The items identified and their conditions are as follows.

1. LONGITUDINAL CONTROL SYSTEM

a) Elevator Actuators - Appendix A, Figures 1 and 2 (4 of 6 recovered)

- 1) P/N: N/A (Not Available – Nameplate missing or unreadable)
S/N: N/A
Appendix A, Figure 3

Description: Elevator PCA, A-frame, and trunion connected to the elevator hinge. Housing module and input linkages not attached. Piston extended 7 and 5/16 inches from actuator housing to rod end bolt center.

- 2) P/N: N/A
S/N: N/A
Appendix A, Figure 4

Description: Elevator PCA, A-frame, and trunion connected to the elevator hinge. PCA attachment to trunion is broken, the PCA rod does not extend through the trunion. Bracket and shims are still present on PCA rod. Housing module and input linkages not attached. Piston extended 6.0 inches from actuator housing to rod end bolt center.

- 3) P/N: S252T801-3
S/N: 638
Appendix A, Figure 5

Description: Elevator PCA, A-frame, and trunion connected to the elevator hinge. Housing module present but not attached to cylinder. Input linkages attached to housing module and piston rod. The bearing in the input linkage between the housing and the input arm is no longer in its proper position in the input arm. Elevator PCA pogo attached to PCA, one rod end is missing. Piston extended 4 and 1/4 inches from actuator housing to rod end bolt center.

- 4) P/N: S252T801-4
S/N: 1778

Description: Elevator PCA intact. A-frame, and trunion connected to the elevator hinge. Housing module, input linkages and pogo are attached. The entire PCA assembly is still attached to the center position in the right elevator. The input linkages are still attached to push rods going to the other actuator positions. The hydraulic lines for the PCA are present, but are broken in one place and are not connected to the PCA. Piston extended 6.0 inches from actuator housing to rod end bolt center.

- b) Miscellaneous Housing Parts: Four PCA housings were found. The conditions ranged from virtually intact to fragments of housing containing the input arm connection.
- c) Miscellaneous Pogos: Two pogos were found. The rod ends were broken or missing, and the cases were split.
- d) Feel and Centering Unit

P/N: 251T2210-13
S/N: 343

Description: Housing is intact. Input arms from both the left and right torque tubes are present, the arm to the left torque tube is still connected at both ends, but is bent in the middle. The feel actuator (P/N 65-44503-10, S/N 1090) is intact, but is disconnected from the feel and centering unit body on the left end. The internal mechanisms are present except for the springs. The centering cam is present, but the centering spring is missing.

e) Stick Nudger Actuator - Appendix A, Figure 6

P/N: R584M54

S/N: 880602

Description: Actuator housing is intact, with the electrical connector on one side missing. The rubber boot is present, and the rod end along with some connecting rod is attached. The measurement from the rod end bolt center to the actuator housing is 6 and 7/8 inches.

f) Elevator Feel Computer

P/N: S251T220-8

S/N: 353

Vender P/N: 162000-105

Description: Both the sections powered by the left hydraulic system and the center hydraulic system were found as separate units. Housings were intact but cracked. Bellows sections were missing.

h) Elevator Aft Torque Tubes
(2 of 2 recovered)

Left: Broken into two sections. The top three lugs are intact, with the connecting rod to the feel and centering unit still connected. The second lug has a portion of a torque tube connected. The fourth lug is broken. The breakout spring stop is intact, but the spring is missing. The quadrant is present, but is bent. The lower section contains the lug for the input arms which go to the PCA's and the bottom lug which goes to structure.

Right: Still in one piece. The top lug has part of a torque tube attached. The second and third lugs from the top are present. The breakout spring stop is intact, and the spring is present and attached. The left half of the quadrant is present and bent, but the right half is missing. The next lug down, which goes to the input rods for the PCA's, is present and contains a rod end. The lower part of the tube and the lug going to structure are missing.

h) Elevator Autopilot Actuators - Appendix A, Figure 7
(2 of 3 recovered)

- 1) P/N: S252T401-8
S/N: 0973, Right hydraulic system - Right hydraulic system designation determined from IPC and M273 label on mounting.
Description: Actuator body is intact. Output arm is present and bent. Electrical connector is missing. One solenoid valve is broken. LVDT's are present but one is bent around the housing.
- 2) P/N: S252T401-8
S/N: 0955, Left hydraulic system - Left hydraulic system designation determined from IPC and M273 label on mounting.

Description: Actuator body is intact. Output arm is present and bent. Electrical connector is present. One solenoid valve is broken, the other one is intact. EHSV is broken. LVDT's are present and both are bent.

i) Miscellaneous Elevator System Components

1. Input crank assemblies:
P/N: 252T2118-2;
P/N: N/A;
Both assemblies were attached to the temperature compensating rods. Both units were identified as coming from the left elevator since all three assemblies for the right elevator were still present in the recovered section. One unit has the rod end for the pogo attached. One unit had the shear rivet broken, and the two arms could move freely in relation to each other.
2. Aft support fittings (trunions):
P/N: 252T2172-1;
Three units, two attached to inboard and outboard positions of the right elevator structure, and one attached to part of left elevator structure. The trunion from the left elevator was determined to be either the middle or inboard fitting due to location of the hydraulic fittings nearby.
3. Lost motion assembly from left elevator:
P/N 251T2416-?;
attached to part of left elevator structure – determined to be left elevator structure due to the orientation of the lost motion device and the structure.

2. LATERAL CONTROL SYSTEM

a) Outboard Aileron Actuators - Appendix A, Figure 8 (2 of 4 found)

1. P/N: N/A
S/N: N/A
2. P/N: 252T102-3
S/N: 424

Description: The actuator cylinders and housings are present. The input linkage on actuator number 1 is complete including the input rod. The input linkage on actuator number 2 has only input arm and part of the next linkage present. The reaction links for both actuators are present. The actuator rods both measured 4 and ½ inches from the edge of the actuator body to the center of the rod end bolt.

d) Inboard Aileron Actuators - Appendix A, Figure 9 (3 of 4 found)

1. P/N: N/A
S/N: N/A
2. P/N: N/A
S/N: N/A
3. P/N: N/A
S/N: N/A

Description: All three actuator cylinder bodies were present. They were all connected to fragments of the aileron surface, and the reaction links (P/N: 252T1171-5) are all attached. On PCA number 3, the feedback links are still attached to the piston. None of the PCA's has housings attached, although one housing was recovered. Only a small amount of the housing body was missing. The rod extensions as measured from the edge of the cylinder to the center of the rod end bolt were as follows:

PCA number 1: 8 and ¼ inches;
PCA number 2: 7 inches;
PCA number 3: 5 and ½ inches.

c) Outboard Spoiler Actuators
(6 of 8 found)

1. P/N: 252T1401-3
S/N: 2407
2. P/N: 252T1401-3
S/N: 2393
3. P/N: 252T1401-3
S/N: 2406
4. P/N: 252T1401-3
S/N: N/A
5. P/N: 252T1401-3
S/N: 2408
6. P/N: 252T1401-3
S/N: 2388

Description: The cylinders and housings for all six actuators are present with minor damage on all units. The electrical connections are intact on units 2 and 3, present but pulled from the housing on units 3, 4, and 5, and missing altogether on unit 6. The piston is missing from unit 3. All of the units except for unit 6 are still attached to some support structure, although unit 4 is only attached by wiring from the electrical connector. Measurements (from the cylinder body edge to the center of the rod end bolt) as follows:

Actuator number 1: 2 inches

Actuator number 2: 3 and $\frac{3}{4}$ inches

Actuator number 3: Missing piston

Actuator number 4: 2 inches

Actuator number 5: 4 and $\frac{1}{8}$ inches

Actuator number 6: 3 and $\frac{3}{8}$ inches.

d) Inboard Spoiler Actuators
(4 of 4 found)

1. (Wing) Position number 5, P/N: 252T1301-3
S/N: 1210
2. Position number 6, P/N: 252T1301-3
S/N: 1212
3. Position number 7, P/N: 252T1301-3
S/N: 1238
4. Position number 8, P/N: 252T1301-3
S/N: 1237

Description: All four actuator bodies are present. The EHSV valve for actuator number 5 is missing, and the other 3 are damaged. The electrical connectors are present for actuator number 8, the electrical connectors for actuators numbers 5 and 7 are missing completely, and the electrical connector for actuator number 6 is present but pulled out of the actuator body. Actuators number 5, 6, and 8 are still in some of their original attaching structure, but actuator number 7 is loose, with no structure present. The piston for actuator number 5 is broken. The piston for actuator number 7 is broken and the rod end is missing, and the pistons for actuators numbers 6 and 8 are present and attached to structural pieces. The piston measurements (from the edge of the actuator cylinder to the center of the rod end bolt) are as follows (actuators numbers 5 and 7 no longer had intact pistons):

Actuator Number 8: 4 and ¼ inches;
Actuator Number 6: 4 and ¼ inches.

e) Lateral Central Control Actuators (LCCA)
(3 of 3 found)

1. P/N: N/A
S/N: N/A
2. P/N: N/A
S/N: N/A
3. P/N: N/A
S/N: N/A

Description: With the exception of LCCA number 2, the actuator bodies are intact. LCCA number 2 has a significant portion of the boost piston wall missing. On LCCA number 1, the LVDT's are both present but bent, LCCA number 2 has one present and bent, LCCA number 3 has no LVDT's present. There are no output arms present on any of the actuators.

f) Outboard Aileron Lockout Mechanism - Appendix A, Figures 10 and 11
(1 of 2 found)

P/N: N/A

S/N: N/A

Description: Identified to be from the left side due to the orientation of the lockout assembly and from the assembly part number on a structural part (251T1701-19). The electrical connector is still attached, and the actuator body is intact with minor separation of the housing from the end cap. Some parts of the mechanism are missing, and the rest are present but bent. The rod is bent slightly and measures (from the actuator housing to the center of the rod end bolt) 4 and ¼ inches.

g) Miscellaneous Aileron Components

One inboard aileron hanger link (P/N 252T1172-5) was recovered.

One spoiler override actuator was found separate from the inboard spoiler actuator assembly. The unit had its rod extended 1 and ½ inches from actuator cylinder edge to the tip of the piston.

The inboard aileron droop override mechanism (P/N: 251T1618-11) was found. Many parts were missing, and one spring was attached at one end.

3. DIRECTIONAL CONTROL SYSTEM

a) Rudder PCA's
(3 of 3 found)

1. P/N: N/A
S/N: N/A (lower PCA)

2. P/N: N/A
S/N: N/A

3. P/N: N/A
S/N: N/A

Description: All three actuator cylinders are intact and attached to the A-frames and hanger beams. The lower actuator still has the housing attached. Two other housings were recovered, but are not attached to the cylinders. The lower actuator (number 1) is still attached by hydraulic lines to the fin structure. The other two actuators are not attached to the fin structure. The input control rod for the lower actuator is connected to the PCA and to the module transfer crank (breakout). Two other module transfer cranks (breakouts) were recovered, but were not attached to the housings or PCA input linkages. The approximate rod extension measurements (taken from the actuator cylinder body to the center of the rod end bolt) were as follows:

PCA number 1: 4 and $\frac{3}{4}$ inches;

PCA number 2: 8 and $\frac{1}{2}$ inches;

PCA number 3: 6 and $\frac{3}{8}$ inches;

b) Yaw Damper Servos
(2 of 2 found)

1. P/N: S252T704-11
S/N: 414 (right side of fin, center hydraulic system)
2. P/N: N/A
S/N: N/A (left side of fin, left hydraulic system)

Description: The yaw damper servos are intact and are both attached to the fin structure. The connecting rod between the two yaw damper output rods is present, but the connecting rod to the yaw damper summing lever mechanism is missing. The electrical connectors are present and seated in the housing. The hydraulic lines are present, but are broken and are no longer connected to the servos. The solenoid valve for servo number 1 is broken off, the solenoid valve for servo number 2 is present but bent. The EHSV's are both present, but the top cover for the EHSV on the number 2 servo is broken. The yaw damper pogo assembly is present but detached from the upper mounting lug. The yellow control rod is disconnected from the summing lever mechanism and the center PCA input linkage.

c) Directional Autopilot Actuators
(3 of 3 found)

Left: P/N: S252T703-5
S/N: 0925

Center: P/N: S252T703-5
S/N: 0922

Right: P/N: S252T703-5
S/N: 0916

Description: All three actuators are intact and were found in place on the fin structure. The output arms and torque tubes (the torque tubes are bent) are all attached as are the EHSV's and solenoid valves. The electrical connectors are intact, with some minor damage. The hydraulic lines are present, but some are broken away from their connections.

d) Other Directional Control System Components

1. Feel and Centering Spring: P/N: 251T3238-1. The spring is intact, but broken away from its mounting (aft quadrant torque tube). The springs are both present and attached. All of the internal linkages are present.
2. Rudder Trim Actuator: P/N: S251T320-2, S/N: 696A. The housing body is intact, but the electrical connector housing is broken away. The actuator has broken away from its mounts on both sides. The length of the actuator, measured from the housing edge to the rod end bolt center is approximately 5 and 1/4 inches.
3. Rudder Aft Quadrant: P/N: 251T3215-12. The quadrant is bent at both ends with a control cable attached to the lower end. The aft quadrant torque tube (to which the quadrant is attached) is intact except for the feel and centering unit and one other lug.
4. Rudder Ratio Changer: P/N: S251T360-6, S/N: 113. The rudder ratio changer torque tube mechanism is disconnected from the fin structure. The rudder ratio changer actuator is intact, with 2 of 3 hydraulic lines intact. The EHSV is present, but bent slightly. The blue control rods are attached to the aft quadrant torque tube, but are disconnected from the rudder ratio changer torque tube. Both rudder ratio changer return springs are present and their linkage is still connected to the actuator. The rudder ratio changer LVDT is present, but the mounting on the rudder ratio changer side is disconnected.

The white control rod is disconnected. The measurement from the actuator housing to the rod end bolt center is approximately 3 inches.

5. Load Limiter Rod (Primary Load Path Control Rod (Crush Core)):
The load limiter is connected at the rudder ratio changer end but is disconnected from summing lever mechanism.

4. STABILIZER TRIM CONTROL SYSTEM

a) Stabilizer Trim Module (2 of 2 recovered)

1. P/N: S252U200-101
S/N: 039

Description: Housing is intact with minor cracks. Electrical connectors present but not seated in housing. Two of four solenoid valves are present, but damaged. Some hydraulic lines attached.

2. P/N: N/A
S/N: N/A

Description: Housing is intact with minor cracks. Electrical connectors present but not seated in housing. All four solenoid valves are broken off. Some hydraulic lines attached.

b) Stabilizer Trim Actuator Assembly: Broke into four major pieces. The pieces are described individually below.

1. Stabilizer Trim Ballscrew

Description: Lower portion of ballscrew. The end-stop is still attached which designates this as the bottom of the ball screw. The length of the ballscrew as measured from the bottom of the end-stop to the fractured end is approximately 21 and 1/2 inches.

2. Stabilizer Trim Ballscrew Actuator

P/N: 251T4310-1
S/N: 0294

Description: Housing is intact, cover for the gears is missing. The ballscrew is broken away from the actuator, with approximately 3/4 inches protruding from the actuator.

3. Stabilizer Trim Ballscrew (Motor/Brake) Housing

P/N: 251T4322-1

S/N: N/A

Description: Housing intact, some minor cracks on the lower joint with attaching structure. One of four input shafts intact but bent.

4. Stabilizer Trim Lower Gimbal Assembly

P/N: 251T4321-1

S/N: 0289

Description: Assembly is intact with ballscrew present and broken at both ends. The ballscrew measures approximately 20 inches from end to end. The top portion of the ballscrew extends above the housing approximately 4 and 1/4 inches. The bottom portion of the ballscrew extends below the housing approximately 1/2 inch.

c) Stabilizer Trim Limit Switch and Position Transmitter Module Assembly (3 of 3 found)

1. P/N: N/A
S/N: N/A

2. P/N: N/A
S/N: N/A

3. P/N: N/A
S/N: N/A

Description: Portions of all three position transmitter module assemblies were found. Assembly number 1 has the associated pulley, bracket, and limit switch can attached, but the limit switch can is broken away from the housing and hanging by its wires. Assembly number 2 has the pulley and bracket attached, as well as portions of internal components of the limit switch can. Assembly number 3 consists of the pulley and bracket only. Additionally, one limit switch can was found that was separated from the position transmitter pulley. The detached limit switch can is bent, and contains four limit switches.

5. OTHER FLIGHT CONTROL SYSTEM COMPONENTS

a) High Lift System

The following items were found:

12 leading edge slat rotary actuators (P/N: 256T2151-5, S/N: 6384 (left wing), 5640 (left wing), 6396 (left wing) – remaining 9 do not have serial numbers remaining). Note: Positions on wing determined from EgyptAir maintenance records;

8 offset gear boxes leading edge slat (P/N: 654T0387-23);

2 offset gear boxes trailing edge flaps (P/N: 256T3570-3, S/N: 321 right wing from EgyptAir listing, and P/N: 256T3570-5, S/N: 297 - left wing from EgyptAir maintenance records);

4 flap rotary actuators (P/N: 256T3250-2, S/N: 1627 and 774 - other units had no labels);

Many other miscellaneous gears and housings.

b) Miscellaneous Rods, Tubes, and Pulleys

A large number of flight control push rods, torque tubes, and pulleys were collected. Most of the items were bent or broken. Many of the items had part numbers, but the exact locations of the parts were not determined.

6. HYDRAULIC SYSTEM

Pumps: A total of 3 (of 4) ACMP's (alternating current motor pumps) (P/N: 271T4540-14) were found. Two of the three motors had pumps attached. The motors and pumps of all units were damaged. One ADP (air driven pump) hydraulic pump was found in a damaged condition.

Other components:

A large pile of miscellaneous hydraulic tubing and fittings was recovered. Many other hydraulic components were found. Included in these components were:

2 (of 2) normal anti-skid valve modules (P/N: S283T001-8, S/N: 038901539 and 038901556) ;

2 (of 2) alternate anti-skid valve modules (P/N: S283T001-17, S/N: 048901630P and 038901603P);
 Nose gear selector valve (P/N: S273T403-4, S/N: V0329);
 Nose gear check valve (P/N: 257T6112-3, S/N: 02224);
 Anti-skid shuttle valve;
 2 (of 2) main landing gear door actuators;
 1 (of 2) door operated sequence valve;
 Shut off valve module – flap and slat (P/N: S256T006-10, S/N: 108-266);
 6 hydraulic EDP and ADP filter modules (3 each of two types);
 5 transfer cylinders (of three different sizes) (P/N: 60B00273-101, S/N: 8900744 and 8802682; P/N: 60B00273-103-01, S/N: 8809187 and 8809183; and P/N: 60B00273-105, S/N: 8808700);
 Return filter;
 2 (of 2) main landing gear door actuators;
 Hydraulic Compensator (P/N: S271T480-1, S/N: 0146)
 Hydraulic Motor (P/N: MF2009-2A, S/N: MX4734242)
 2 hydraulic fuses (P/N: 60B00238-13, S/N: 8082311);
 2 motor operated bypass valves (P/N: S256T005-4 S/N: 48-1150, and P/N: S256T005-8, S/N: 86-2693);
 2 motor selector valves;
 2 (of 2) Door operation valve sequence module (P/N: S273T402-6, S/N: 00673, and N/A)
 Brake system components;
 3 lateral control shutoff valves;
 Shutoff/isolation valve;
 2 slat and 2 flap hydraulic drive units;
 Other unidentified parts.

In addition, the support beam, hydraulic pump, and the turbine section (without blades) for the ram air turbine were found.

7. FUEL SYSTEM

a) Pumps:

Two (of two) main tank boost pump assemblies (containing a total of 4 individual pumps) and one (of two) center tank override pump assemblies were found. The pump assemblies were all slightly damaged with parts of the housings missing, and all of the pumps were present inside the housings.

b) Other

Other fuel system components found included 3 hydraulic system heat exchangers, 3 compensators, valves, segments of pressure refueling lines and

parts of fuel probes. Two of the three densitometer emitters were recovered. The Rhode Island Air National Guard dispatched a team to check the emitters for leakage. The emitters did not appear to be leaking radiation in any direction other than the designed direction.

8. ELECTRICAL SYSTEM

a) Avionics Boxes

A large pile of avionics box remnants was recovered. The remnants of the boxes were generally just black pieces of metal with most of the interior parts missing. A large quantity of circuit cards was found, but most had the individual chips missing or badly damaged. All of the parts were checked for any signs of arcing, no signs were found. Some of the items gathered may have been consumer electronics, it was difficult to tell them apart.

b) Wiring - Appendix A, Figure 12

A large pile of wiring was collected. Most of the wiring was in short bundles less than 4 feet long. Some bundles extended for approximately 10 feet. All of the bundles were checked for any signs of arcing or burning, none were found.

c) Generators/Motors

Seven motors or generators were found in badly damaged conditions. No part numbers were available.

9. ECS AND PRESSURIZATION SYSTEM

Parts recovered include the door for the outflow valve (separated from its housing), several sections of heat exchangers for the air conditioning packs, parts of the air cycle machines, approximately 15 feet of ducting, and two vacuum blowers.

10. TAIL SKID SYSTEM

The tail skid was recovered intact with the skid retracted.

11. COCKPIT SYSTEMS ITEMS

Several items were found that were identified as coming from the cockpit area. These included:

Center part of a control wheel with the yoke index mark displaced approximately 2 and ¼ inches to the right from the null aileron index mark;

Part of the speed brake handle assembly (the leading edge of the handle was at a position approximately 3 inches from the aft end of the slot);

The cabin pressure selector panel (with the knob flat face in line with the “auto 2” position and the numbers 720 0470 displayed) – Appendix A, Figure 13;

Part of the flap handle assembly;

A primary, electrical altimeter with the numbers 16380 displayed – Appendix A, Figure 14;

A stowed oxygen mask, P/N: MXP 147, S/N: S1003 with a hand written sign on the back labeling the assembly “captain’s side”;

Three force transducer springs (P/N: S253T401-1, S/N: 1781, 1839, and 1852).
Intact, but flattened;

A flight deck dimmer switch P/N: S283T019;

A section of circuit panel containing the anti-ice circuit breaker, labeled P-11-6,
P/N: 233T5227-46.;

Phase III:

The Systems Group met at Quonset Point, Rhode Island during the period of 25-26 February 2000. During that time, they examined each fracture surface on the recovered components of the longitudinal control system. All of the fracture surfaces displayed signs of overstress. The components examined were:

1. Elevator PCA number 1;
2. Elevator PCA number 2;
3. Elevator PCA number 3;
4. Elevator PCA number 4;
5. All fracture surfaces in recovered linkages from the right and left elevators;
6. Miscellaneous housings pieces 1, 2, 3, and 4;
7. Longitudinal Feel and Centering Unit;
8. Elevator left and right aft torque tube;
9. Large pile of 91 miscellaneous control rods;
10. Stick nudger;
11. Stabilizer jack screw piece in motor;
12. Stabilizer jack screw piece in gimbal nut;
13. Stabilizer jack screw piece – loose.

Note: This piece was taken to the Safety Board materials laboratory in Washington, D.C. for further examination. This more detailed examination revealed that all of the fracture surfaces were a result of overstress.



Scott A. Warren

Aerospace Engineer

